METHODS AND COSTS FOR THE WAREHOUSE ASSEMBLY OF GROCERY ORDERS FOR SMALL STORES

Marketing Research Report No. 1031

Agricultural Research Service

UNITED STATES DEPARTMENT OF AGRICULTURE

PREFACE

This study was conducted under contract with Robert C. Middaugh and Assoc., a warehouse consulting and engineering firm, Charleston, S.C. The contract was administered by John C. Bouma, Chief, Market Operations Research Laboratory, Agricultural Marketing Research Institute.

Special acknowledgment is due to Associated Wholesale Grocers, Kansas City, Kans.; E. J. Keefe Co., Inc., Lakeland, Fla.; Kimbell Co., Albuquerque, N. Mex.; Alfred M. Lewis, Inc., Phoenix, Ariz.; Merchants Distributors, Inc., Hickory, N.C.; Perloff Brothers, Inc., Philadelphia, Pa.; C. B. Ragland Co., Nashville, Tenn.; P. A. & S. Small Co., York, Pa.; Thriftway Foods, Inc., King of Prussia, Pa.; Hudson-Thompson, Inc., Montgomery, Ala.; and others who provided facilities and data for the study.

CONTENTS

Washington, D.C. Issued September 1975

METHODS AND COSTS FOR THE WAREHOUSE ASSEMBLY OF GROCERY ORDERS FOR SMALL STORES

By Errol R. Bragg, Jack L. Runyan, and John C. Bouma[1]

SUMMARY

Five combinations of methods were studied for assembling and delivering grocery orders from wholesale warehouses to small retail stores. Cost and productivity data were developed for 5 order sizes by number of cases—more than 75, 61 to 75, 41 to 60, 25 to 40, and less than 25—in each of the following 5 methods:

1. Long selection line, orders assembled on tow tractors and four-wheel selector trucks and delivered by hand-stacked truckloads.
2. Long selection line, orders assembled on tow tractors and collapsible carts and delivered on collapsible carts.
3. Short selection line, orders assembled on tow tractors and four-wheel selector trucks and delivered by hand-stacked truckloads.
4. Short selection line, orders batch assembled on tow tractors and collapsible carts and delivered on collapsible carts.
5. Multilevel selection line, orders assembled on high-lift trucks and collapsible carts and delivered on collapsible carts.

Two procedures for order checking—piece count and item description—were also analyzed.

This study indicates that wholesalers who supply groceries to small retail stores should:

- Use a short selection line to concentrate all items usually ordered by small stores in one area of the warehouse rather than to permit items to be scattered throughout the warehouse, as with the long selection line.
- Assemble more than one store's order at a time (batch selection).
- Use piece-count checking.
- Deliver the orders on collapsible carts.

This last method had the lowest costs and highest productivity in each of the five order sizes. The major factor that contributed to the lower costs was the high order-selector productivity that resulted from batch order selection. Order-selector productivity was at least double that of other methods, except where multilevel order selection was used. Piece-count checking increased checking productivity by 75 percent.

Although batch selection lowered costs the most, other aspects of this method (No. 4) contributed significantly to its being the most economical method for assembling and delivering grocery orders. The use of collapsible carts increased truck-loading productivity per man-hour from 291 cases using hand-stacked loading to 1,223 cases and reduced costs by $1.21 per 100 cases. Unloading productivity per man-hour increased from 140 cases using hand unloading (two-wheel trucks) to 216 cases using collapsible carts and decreased costs by $1.10 per 100 cases. Implementing a short selection line could reduce order-selector costs up to 35 percent, compared with costs for a long selection line.

[1] Respectively, marketing specialists, Food Distribution Research Laboratory, and Chief, Market Operations Research Laboratory, Agricultural Marketing Research Institute, Northeastern Region, Agricultural Research Service, Beltsville, Md.

Of the five methods, the long selection line, tow tractor, and four-wheel selector truck method (No. 1) had the highest total cost range. Costs were from $12.10 per 100 cases for the 61-to 75-case order to $16.61 for the less-than-25-case order. (No data were available for the more-than-75-case order for this method.) Total costs for the least expensive method (No. 4) ranged from $5.82 per 100 cases for the more-than-75-case order to $8.66 for the less-than-25-case order. The difference resulted in an average savings of $7.10 per 100 cases between the two methods. The quoted amounts do not include building, supervision, utility, sales, administrative, office, or variable delivery costs.

INTRODUCTION

Many affiliated wholesalers have developed efficient warehouse, delivery, and sales operations to service supermarkets and larger superette retail outlets. Because the sizes of the warehouses and the delivery fleets are geared to the efficient servicing of relatively large orders, costs to assemble and deliver orders to convenience and other small stores are relatively high.

During the 20 years preceding 1974, urban development fostered wide growth of regional supermarkets and largely displaced the familiar neighborhood grocery store. However, the consumer still considers convenience. Of the 199,560 retail foodstores operating in 1973, 121,100, or nearly 61 percent, had annual sales of less than $150,000 and were classified as small stores. In 1973, small stores accounted for nearly 10 percent of foodstore sales.[2] Many small stores do not pretend to be a complete retail grocery operation, but extended hours and ready accessibility to consumers have made them successful.

During the decade 1964-74, a relatively new concept in food retailing has developed rapidly. This concept includes the establishment of small, modern stores that operate from early morning until late at night and that are located in areas of relatively high population concentration. The term "convenience stores" has been used to describe this new type of operation. Convenience stores are supplied largely by grocery wholesalers who have found a substantial business available if they can develop a method or system to supply these stores efficiently.

The overall objective of this study was to determine and compare the costs of using various combinations of layouts, equipment, and checking procedures for assembling and delivering grocery orders from wholesale warehouses to small retail stores. Costs and productivity for 5 order sizes—more than 75, 61 to 75, 41 to 60, 25 to 40, and less than 25 cases—were measured for each method. More specifically, the objectives were to determine and compare the labor and equipment costs for each order size for the following functions:

1. Order Assembly
   - (a) Long selection line using tow tractors and four-wheel selector trucks.
   - (b) Long selection line using tow tractors and collapsible carts.
   - (c) Short selection line using tow tractors and four-wheel selector trucks.
   - (d) Short selection line using tow tractors and collapsible carts.
   - (e) Multilevel selection line using high-lift trucks and collapsible carts.
2. Delivery
   - (a) Order checking by item description.
   - (b) Order checking by piece count.
   - (c) Truck loading and unloading resulting from the use of four-wheel selector trucks for order assembly.
   - (d) Truck loading and unloading resulting from the use of collapsible carts for order assembly.

[2] Progressive Grocer 53 (4): 71. April 1974.

METHODOLOGY

Nine grocery warehouse operations were selected for analysis. The warehouse operations studied had the following characteristics: (1) Three used long selection lines and assembled orders with tow tractors and four-wheel selector trucks; (2) two used long selection lines and assembled orders with tow tractors and collapsible carts; (3) two used short selection lines and assembled orders with tow tractors and four-wheel selector trucks; (4) one used a short selection line and assembled orders with tow tractors and collapsible carts; and (5) one used a multilevel selection line and assembled orders with high-lift trucks and collapsible carts. The warehouse operations studied were conducted in facilities from 150,000 to 250,000 square feet in area; these facilities were used primarily for supplying supermarkets. During the study, the number of firms that used collapsible carts to deliver orders to small stores was not as great as the number of firms that used conventional hand-stacking methods, such as loading by hand.

At each warehouse, a minimum of 60 grocery orders was studied, 20 for each of the following size orders: 25 to 40 cases, 41 to 60 cases, and 61 to 75 cases. Cost data for labor, equipment, and delivery were obtained from the financial records of the nine warehouses and were averaged by type of equipment and selection line to eliminate differences that resulted from geographical location. However, additional warehousing costs such as building, supervision, utility, sales, administration, office, and delivery charges (except for driver's unloading) were not used in this study and were excluded from all cost comparisons.

Production standards for warehouse operations and retail store receiving operations, which include a 15-percent personal-and-fatigue allowance, were based on improved work methods developed through previous research in grocery handling. The jobs were divided into elements, and the time required to perform the elements was measured with a stopwatch. The time for the various elements was then adjusted to reflect the speed of the average operator working at a normal pace.

WAREHOUSE LABOR COSTS

Analysis of labor at the warehouse was limited to "touch labor," or labor directly involved in handling grocery cases in the order-selecting and truck-loading operations. Touch labor, as used in this study, does not include forklift servicing of pallet racks.

Order Selection

Warehouse order selection consists of all work performed by the order selector from the time that he obtains an invoice (list of items and cases ordered) until the order is completed and placed at the loading dock.

The terms "long selection line" and "short selection line" are relative. In warehouses where long selection lines are used, order selectors travel throughout the entire warehouse to assemble a retail customer's order, whether the customer is a large supermarket or a small store. However, these warehouses have a separate order list that specifies the amount of items that convenience stores are permitted to order. Where short selection lines are used, the items ordered by small retailers are concentrated in one area of the warehouse. This technique limits the distance traveled by order selectors in assembling orders for small stores.

In multilevel selection, an order selector picks from many pallet rack levels of product storage. The maximum selection height may extend to 4 feet below the warehouse ceiling, whereas the stacking height of conventional warehouse operation usually will not exceed 8 feet from the floor. A description of each selection line and equipment follows.

Long Selection Line

Of the five warehouses that had a long selection line, three used four-wheel selector trucks, and two used collapsible carts to select customers' orders. In the judgment of warehouse management in the five firms that have long selection lines, volume, represented by the small store orders was not sufficient to justify changing the selection line. A change in selection line would also disrupt the family grouping of products in the warehouse. Normally, the layout of products in these warehouses is similar to the layout of the supermarkets that they service.

Four-wheel selector trucks.—The four-wheel selector trucks are usually 36 inches wide by 60 inches long. The number of cases placed on the truck depends on the size of the cases, the loading skill of the order selector, and the size of the order. One truck, however, will accommodate approximately the same amount of product (49 cases) as the standard 48- by 40-inch pallet commonly used by food wholesalers. These trucks are rigid, and after they have been loaded by the order selector, the merchandise is checked, unloaded by hand, and stacked in the delivery truck.

No data were available for orders larger than 75 cases (table 1). The size of the average order ranged from 66 cases for the 61- to 75-case order to 15 cases for the less-than-25-case order. Normally, the average order size used in this study begins at 104 cases for the largest order size. Average and total order sizes remain constant throughout this report. Quantities of cases, as used in productivity measurements, are given per man-hour.

For the 61- to 75-case order, order selector productivity was 97 cases, but as order size decreased, order selector productivity decreased also. Order selector productivity ranged from 49 cases for the less-than-25-case order to 97 cases for the 61- to 75-case order, an increase in productivity of 98 percent. The reasons for this increase were: (1) The order selector's total travel time remained about the same, but the number of cases selected increased; and (2) the pick density (the number of cases selected divided by the number of items ordered) was greater for large orders.

Selection labor costs per 100 cases for the long selection line, four-wheel selector truck method ranged from $4.33 for the 61- to 75-case order to $8.57 for the less-than-25-case order. Considerably more merchandise was being selected for the larger order size than for the smaller order size during approximately the same amount of time. Therefore, cost per case was lower.

Collapsible carts.—Collapsible carts are available in two sizes either 29 inches wide by 59 inches long by 72 inches high, or 27 inches wide by 57 inches long by 71 inches high. Collapsible carts also hold approximately the same amount of product as the standard 48- by 40-inch pallet (49 cases). Unlike the four-wheel selector trucks, collapsible carts are often more

TABLE 1.—*Order size, selector productivity and cost with long selection lines, tow tractors, and four-wheel selector trucks*

Total order size	Average order size	Order selector productivity per man-hour	Selection cost per 100 cases[1]
Cases	*Cases*	*Cases*	*Dollars*
More than 75	(2)	(2)	(2)
61 to 75	66	97	4.33
41 to 60	49	78	5.38
25 to 40	32	66	6.36
Less than 25	15	49	8.57

[1] Computed on an estimated labor cost of $4.20 per man-hour ($4.20 per man-hour ÷ 97 cases per man-hour x 100 cases = $4.33 per 100 cases).

[2] No observations available for this order in the firms studied.

convenient for warehousemen and retailers because once products are placed on the carts during order selection, they remain there until they are unloaded for shelf stocking at retail stores. As the name implies, they are collapsed and returned to the warehouse when a subsequent order arrives at the retail store.

Order selector productivity ranged from 84 cases for the more-than-75-case order to 50 cases for the less-than-25-case order (table 2). Compared with the 97 cases (61- to 75-case order) for the long selection line—four-wheel selector truck method (table 1), order selector productivity with the long selection line—collapsible cart method was 74 cases (61- to 75-case order), or 23 cases less. The lower productivity of the collapsible cart method was due primarily to erecting the carts before order selection and to working around the shelf of the cart when selecting larger orders.

In both methods, the order selector had to travel the entire warehouse regardless of the order size. Although there was a 23-case difference in productivity between the four-wheel selector truck method and the collapsible cart method for the 61- to 75-case order, the difference became smaller as the order sizes decreased. Order selector productivity per man-hour for the less-than-25-case order was almost equal: 49 cases with four-wheel selector trucks and 50 cases with collapsible carts.

Selection labor costs for the long selection line—collapsible cart method decreased from $8.40 per 100 cases for the less-than-25-case order to $5 for the more-than-75-case order (table 2). Costs increased by $1.35 ($5.68-$4.33) or by 31 percent over the four-wheel selector truck method for the 61- to 75-case order (table 1). Although selection costs were higher for the 61- to 75-case order with the long selection line—collapsible cart method, they were 2 percent lower than with the long selection line—four-wheel selector truck method for the less-than-25-case order. Selection costs for the long selection line—collapsible cart method were higher than for any of the other methods studied, except for the less-than-25-case order, where the long selection line—four-wheel selector trucks had higher costs.

Short Selection Line

All the warehouses used the same equipment, whether they had a short or a long selection line. However, batch selection, an improved technique in order selection, was used in one warehouse. Batch selection is filling two or more orders simultaneously by an order selector. The warehouses using short selection lines allocated a certain section of their facilities to handle products usually ordered by small stores. Their volumes were such that warehouse management thought it feasible, both logically and economically, to establish a short selection line by placing items ordered by small stores together in one section of the warehouse; thus, travel time and cost of order selection decreased.

Four-wheel selector trucks.—The order selector productivity for the four-wheel selector truck method shown in table 3 was 103 cases per man-hour for the more-than-75-case order. Order selector productivity was not substantially greater for this method of order selection compared with the long selection line—four-wheel selector truck method. As order size decreased, order selector productivity with the short selection line—four-wheel selector truck method (table 3) decreased by a smaller amount than with the long selection line—four-wheel selector truck method (table 1). For the less-than-25-case order, order selector productivity with the short selection line—four-wheel selector truck method (table 3) was 15 cases (64-49) per man-hour higher than with the long selection line—four-wheel selector truck method (table 1).

Selection costs for the short selection line—four-wheel selector truck method ranged from $4.08 per 100 cases for the more-than-75-case order to $6.56 for the less-than-25-case order. This cost variance was the smallest in any of the order selection methods for which data were available for all order sizes.

Collapsible carts (batch selection).—This technique of order selection was introduced into the short selection line method by one warehouse studied. Batch selection allows an order selector to select two or more orders at the same time, depending on the size of the order. The order selector is equipped with a

TABLE 2.—*Order size, selector productivity, and cost with long selection lines, tow tractors, and collapsible carts*

Total order size	Average order size	Order selector productivity per man-hour	Selection cost per 100 cases[1]
Cases	*Cases*	*Cases*	*Dollars*
More than 75	104	84	5.00
61 to 75	66	74	5.68
41 to 60	49	69	6.09
25 to 40	32	55	7.64
Less than 25	15	50	8.40

[1] Computed on an estimated labor cost of $4.20 per man-hour (4.20 per man-hour ÷ 84 cases per man-hour x 100 cases = $5 per 100 cases).

TABLE 3.—*Order size, selector productivity, and cost with short selection lines, tow tractors, and four-wheel selector trucks*

Total order size	Average order size	Order selector productivity per man-hour	Selection cost per 100 cases[1]
Cases	*Cases*	*Cases*	*Dollars*
More than 75	104	103	4.08
61 to 75	66	99	4.24
41 to 60	49	84	5.00
25 to 40	32	68	6.18
Less than 25	15	64	6.56

[1] Computed on an estimated labor cost of $4.20 per man-hour (4.20 per man-hour ÷ 103 cases per man-hour x 100 cases = $4.08 per 100 cases).

train of two or more carts pulled by a tow tractor (fig. 1). The order selector fills as many orders as his carts can handle; thus, he increases his productivity compared with the conventional selection method.

For small orders of less than a cartload (20 to 25 cases), the order selector can place the products for one store order on the bottom platform of the cart and the products for the other store on the shelf. At the completion of order selection, the selector transfers the products from the shelf of the cart to another cart, at a rate of 10 minutes per 1,000 cases,[3] or 1 minute per 100 cases, for a cost of $0.07 per 100 cases.

With total order sizes and average order sizes still unchanged, order selector productivity in cases per man-hour for the more-than-75-case order increased from 103 with the short selection line—four-wheel selector truck method (table 3), to 258 with the short

[3] Shaffer, P. F., and Runyan, J. L. An Evaluation of Multilevel Order Selection for Low-Volume Grocery Items. U.S. Dept. Agr., Market. Res. Rpt. 1028. 1975.

PN-4046
Figure 1.—Tow tractor and train of four collapsible carts.

selection line—collapsible cart method (batch selection) (table 4). Order selector productivity in cases per man-hour with the short selection line—collapsible cart method ranged from 258 for the more-than-75-case order to 98 for the less-than-25-case order. These 98 cases per man-hour were almost equal to the order selector productivity (103 cases) for the more-than-75-case order in the short selection line—four-wheel selector truck method (table 3). This sizable increase must be attributed partly to the batch selection technique.

With increased productivity, costs decreased proportionately. Selection cost for the more-than-75-case order dropped $2.45 per 100 cases, from $4.08 for four-wheel selector trucks (table 3) to $1.63 for collapsible carts with batch selection (table 4). With batch selection, costs for the short selection line—collapsible cart method were less than for any other method studied.

Multilevel Selection Line

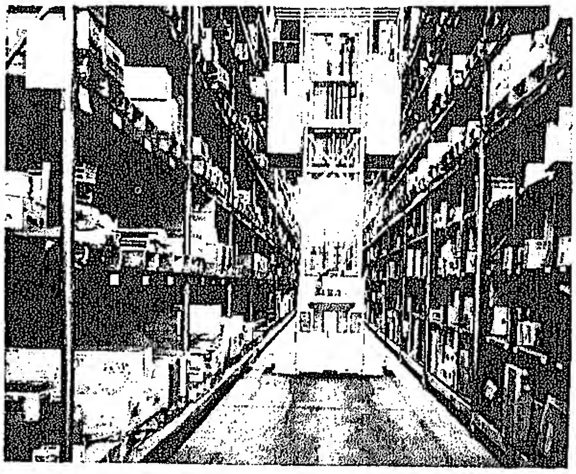
In conventional warehouse operations in the study, products were assumed to be selected from pallet rack storage up to approximately 8 feet above the warehouse floor, with reserve storage on pallet racks above the selection area. However, one warehouse studied used high-lift trucks (fig. 2) and multilevel selection. In multilevel selection, an order selector fills customers' orders from many pallet rack levels of product storage. For multilevel operations, the aisles used for order selection are 6 feet wide, or about 1 foot wider than the equipment.[3] Conventional warehouse aisles are generally 11 feet 6 inches to 12 feet wide. The high-lift trucks are attached to guide rails to provide stability and horizontal guidance. The selector, then, is free from the task of driving and can concentrate on order selection.

Order selector productivity per man-hour with this method, for the more-than-75-case order (table 5), was 155 cases. This productivity was 40 percent less than with batch

TABLE 4.—*Order size, selector productivity and cost with short selection lines-batch selection, tow tractors, and collapsible carts*

Total order size	Average order size	Order selector productivity per man-hour	Selection cost per 100 cases[1]
Cases	*Cases*	*Cases*	*Dollars*
More than 75	104	258	1.63
61 to 75	66	237	1.77
41 to 60	49	210	2.00
25 to 40	32	156	2.69
Less than 25	15	98	4.29

[1] Computed on an estimated labor cost of $4.20 per man-hour ($4.20 per man-hour ÷ 258 cases per man-hour x 100 cases = $1.63 per 100 cases).



PN-4047
Figure 2.—High-lift truck in a multilevel selection warehouse.

selection (258 cases), but 50 percent greater than with the conventional four-wheel truck method (103 cases). No data were available for the less-than-25-case order because the warehouse studied supplied only the stores of its parent corporation and imposed a minimum order size. Order selector productivity in cases per man-hour ranged from 95 for the 25- to 40-case order to 155 for the more-than-75-case order.

Selection cost for the multilevel method was $2.71 per 100 cases for the more-than-75-case order and increased to $4.42 for the 25- to 40-case order size, a difference of $1.71. However, cost decreased by a similar ratio for the short selection line—four-wheel selector truck method.

Based on a U.S. Department of Agriculture report[3] that compares multilevel with conventional order selection, if this firm adopted batch selection, it could increase order selector productivity to approximately 215 cases per man-hour and reduce costs to $1.95 per 100 cases for the more-than-75 order.

Checking and Loading

Checking and loading productivity in cases per man-hour and in cost per 100 cases with the same equipment is shown in table 6. The length of the selection line is not shown because after an order has been selected, the length of the selection line will no longer directly affect productivity or cost, since checking and loading products occurs after order selection has been completed. Totals and average order sizes do not appear in the table because, generally, per case costs for order checking and truck loading remained constant regardless of the order size.

Order Checking

After an order has been selected and loaded on the selection equipment (four-wheel selector trucks or collapsible carts), it must be checked for accuracy before being loaded on delivery trucks. The order-checking procedure

TABLE 5.—*Order size, selector productivity, and cost with multilevel selection lines*

Total order size	Average order size	Order selector productivity per man-hour	Selection cost per 100 cases[1]
Cases	*Cases*	*Cases*	*Dollars*
More than 75	104	155	2.71
61 to 75	66	135	3.11
41 to 60	49	110	3.82
25 to 40	32	95	4.42
Less than 25	([2])	([2])	([2])

[1] Computed on an estimated labor cost of $4.20 per man-hour ($4.20 per man-hour ÷ 155 cases per man-hour x 100 cases = $2.71 per 100 cases).
[2] No observations available for this order size in the firms studied.

TABLE 6.—*Productivity and labor cost for methods of checking, loading, and unloading*

Method	Productivity per man-hour	Labor cost per 100 cases
	Cases	*Dollars*
Checking:		
Item description	1,140	[1]0.37
Piece count	1,992	.21
Loading:		
Hand stacking	291	[2]1.44
Collapsible cart	1,223	.34
Unloading:		
Two-wheel handtruck	140	[3]3.43
Collapsible cart	216	2.22

[1] Computed on an estimated wage rate of $4.20 per man-hour ($4.20 per man-hour ÷1,140 cases per man-hour x 100 cases = $0.37 per 100 cases).
[2] Computed on an estimated wage rate of $4.20 per man-hour (4.20 per man-hour ÷ 291 cases per man-hour x 100 cases = $1.44 per 100 cases).
[3] Computed on an estimated truckdriver's wage rate of $4.80 per man-hour ($4.80 per man-hour ÷ 140 cases per man-hour x 100 cases = $3.43 per 100 cases).

requires the checker to count the number of cases assembled by the order selector and to verify that total with the amount needed to fill the order. Most firms studied used the "item-description method" for checking orders. In this method, the order is checked relative to the number of items of a particular brand ordered.

One firm studied for this analysis, however, varied from this conventional method of order checking. It used the "piece-count method" for checking orders, and thereby increased its checking productivity by 75 percent compared with the other firms studied. In the piece-count method, an order is checked relative to the total number of cases selected by an order selector in comparsion with the total on the invoice. At no time does the checker count the amount of brand X or brand Y ordered case by case unless the totals do not agree. In these circumstances, the checker has to check the entire order item by item if he cannot readily correct the mistake.

Another firm did not check orders; it supplied products only to its store operations and thereby eliminated the necessity of checking orders at the warehouse. If a store received an order with either a surplus or a deficit, this error was simply corrected when the next order was placed. The only checking occurred at the retail store.

A more detailed description of the various methods and costs of order checking is given in Marketing Research Report No. 399.[4] A comparison of the productivity and cost for the two order-checking methods is discussed below.

Item description.—Checker productivity was 1,140 cases per man-hour in those warehouses that used the item-description method for order checking. Increased time and labor for locating specific items with this method resulted in a 75-percent decrease in productivity compared with the piece-count method. The checking cost with the item description method was $0.37 per 100 cases.

Piece count.—Checker productivity increased to 1,992 cases per man-hour (from 1,140 with

[4] Bouma, J. C., and Kriesberg, Martin. Measures of Operating Efficiency in Wholesale Food Warehouses. U.S. Dept. Agr., Agr. Market. Serv., Market. Res. Rpt. 399, 32 pp. May 1960.

item description) with the piece-count method of order checking. The 75-percent increase is attributed to the more expedient piece count checking procedure described earlier. As a result, time and labor are reduced significantly.

Checking cost with the piece-count method amounted to $0.21 per 100 cases, a saving of $0.16 over the item description method. Checking amounts to only a small percent of total servicing costs.

Truck Loading

After the orders were checked, they were loaded on delivery trucks. The influence of method becomes very apparent when productivity and cost for loading and unloading are considered. Loading and unloading can be easy and relatively fast, or they can be strenuous and time consuming, depending on the type of equipment used in order selection. If four-wheel selector trucks are used, the products must be unloaded case by case from the four-wheel selector trucks and stacked by hand into the delivery truck. Considerably more time and manpower are required with four-wheel selector trucks than with collapsible carts.

If collapsible carts are used, labor, time, and cost are minimized. Collapsible carts are simply pushed into the delivery truck. The products are not removed until they are placed on shelves in the retail stores. As carts are loaded in the truck, they are placed in groups of three, one beside the other across the width of the truck. The truckloader secures the carts by attaching a belt to a vertical side member of the truck, by stretching the belt across the front of the carts, and then by attaching it to a similar side member on the opposite side of the truck. The belt is tightened and the process repeated until the truck is loaded or the order is completed, whichever comes first. Some firms used metal load-locking bars to hold the carts in place.

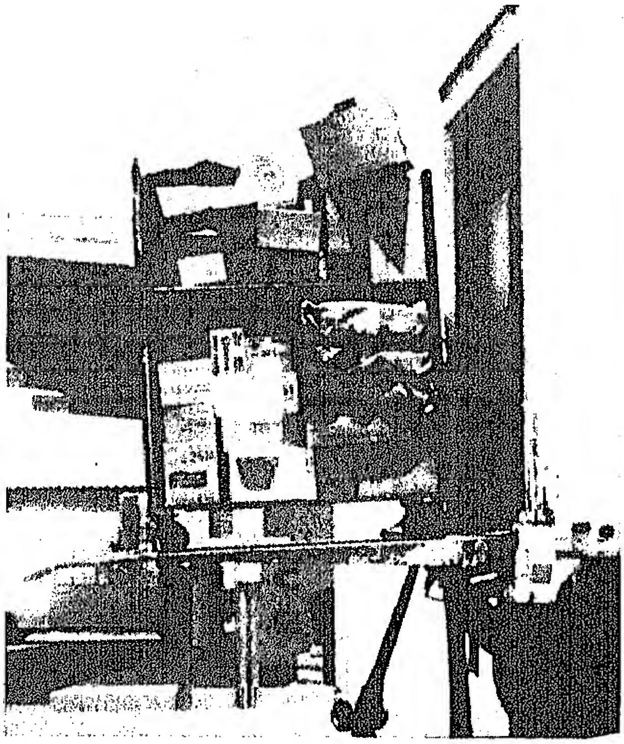
Maximum use of available trailer space is not possible when collapsible carts are used for delivering products. Because carts require space for maneuvering, using them results in smaller payloads than when products are hand stacked in trailers. However, the lower costs for loading and unloading products will offset most losses from smaller payloads if trucks delivering to small retail stores are routed carefully.

Hand stacking.—The productivity rate for loading a delivery truck using the hand-stacking method was 291 cases per man-hour (table 6). This production is not efficient when labor, time, and cost are considered for such an operation. This amount is the normal productivity for a loader, but compared with collapsible carts it is very unproductive. Loading delivery trucks using the hand-stacking method costs $1.44 per 100 cases, one of the higher expenses in servicing retail stores.

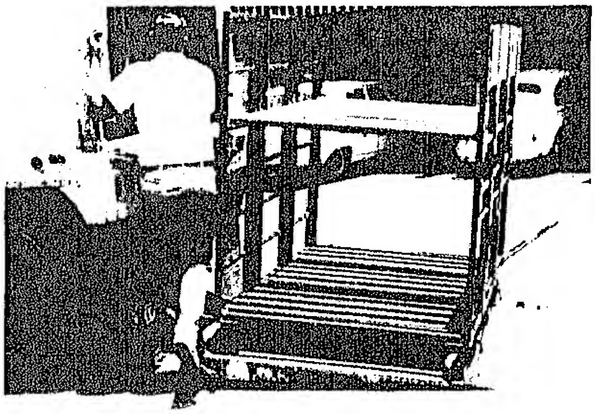
Collapsible carts.—Loading productivity per man-hour with collapsible carts was 1,223 cases (table 6), more than 4 times greater than loading productivity with the hand-stacking method (291 cases). This comparison clearly indicates the relative ease and quickness of loading collapsible carts onto delivery trucks. The cost for loading 1,223 cases per man-hour was $0.34 per 100 cases, or $1.10 less than the cost with the hand-stacking method ($1.44 per 100 cases).

UNLOADING AT THE RETAIL STORE

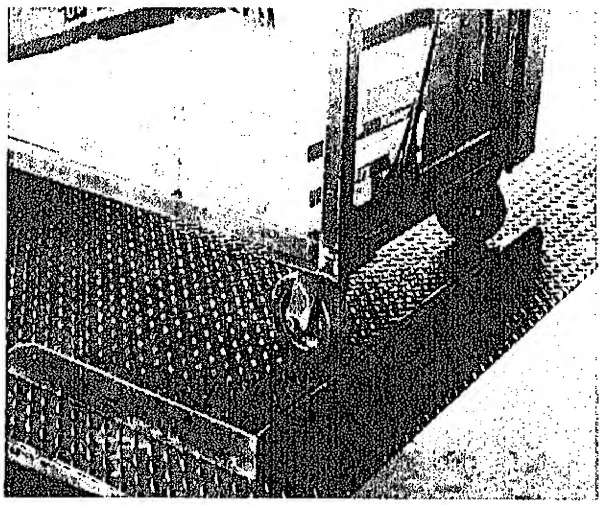
The method of loading determines how the truck will be unloaded. If the truck was loaded case by case from four-wheel selector trucks, the driver must unload the order case by case either onto a two-wheel handtruck, a semilive skid, a four-wheel handtruck, or other platform and wheel the merchandise into the store. (Two-wheel handtrucks were used by firms in this study.) If collapsible carts were used, then a power tailgate (fig. 3) was required on the truck to provide a means for the driver to unload the carts. With such a tailgate, the driver can lower the full carts to the ground or to the store entrance level, unload, and pick up the empties for backhaul (fig. 4). An iron bar fastened to the tailgate (fig. 5) provides stability for the carts while they are being unloaded and empties reloaded on the truck.



PN-4048
Figure 3.—Collapsible cart positioned on a power tailgate before being lowered to the ground.



PN-4049
Figure 4.—Lowered tailgate pickup of empty carts for backhaul.



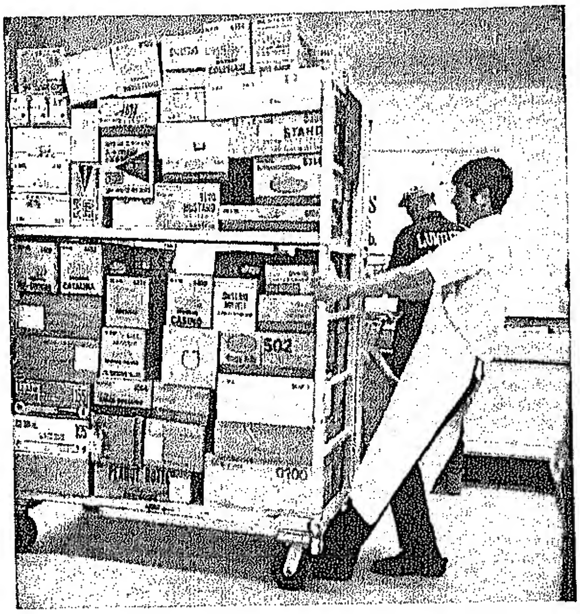
PN-4050
Figure 5.—Iron bar prevents collapsible carts from rolling off the tailgate.

Very few of the small stores have dock facilities that would allow direct loading and unloading of merchandise from the truck. In many instances, the merchandise has to be moved through the customers' entrance. Traffic congestion also causes delays and thereby makes truck unloading a difficult task, regardless of the equipment used. Figure 6 shows a loaded collapsible cart being pulled inside the store.

Two-wheel handtrucks.—Because cases were hand stacked in the delivery trucks and most small stores were not equipped with a loading dock, truck unloading required the driver to: (1) Enter the truck and move several cases to its rear edge; (2) get out and load these cases onto a two-wheel handtruck; and (3) wheel the cases into the store (fig. 7). This process had to be repeated until the store's order was unloaded. As a result of using these two-wheel handtrucks, unloading productivity was 140 cases per man-hour, at a cost of $3.43 per 100 cases (table 6).

Hand-stacked products could also be unloaded from delivery trucks by using gravity conveyors. According to data from an earlier U.S. Department of Agriculture study,[5] productivity for conveyor unloading amounted to 13.9 seconds per case or 259 cases per man-hour. The 13.9 seconds per case consisted of

[5] Shaffer, P. F., Bouma, J. C., Karitas, J. J., and Flynn, Gordon. Handling Groceries From Warehouse to Retail Store Shelves, U.S. Dept. Agr. Market. Res. Rpt. 473, 47 pp. May 1961.



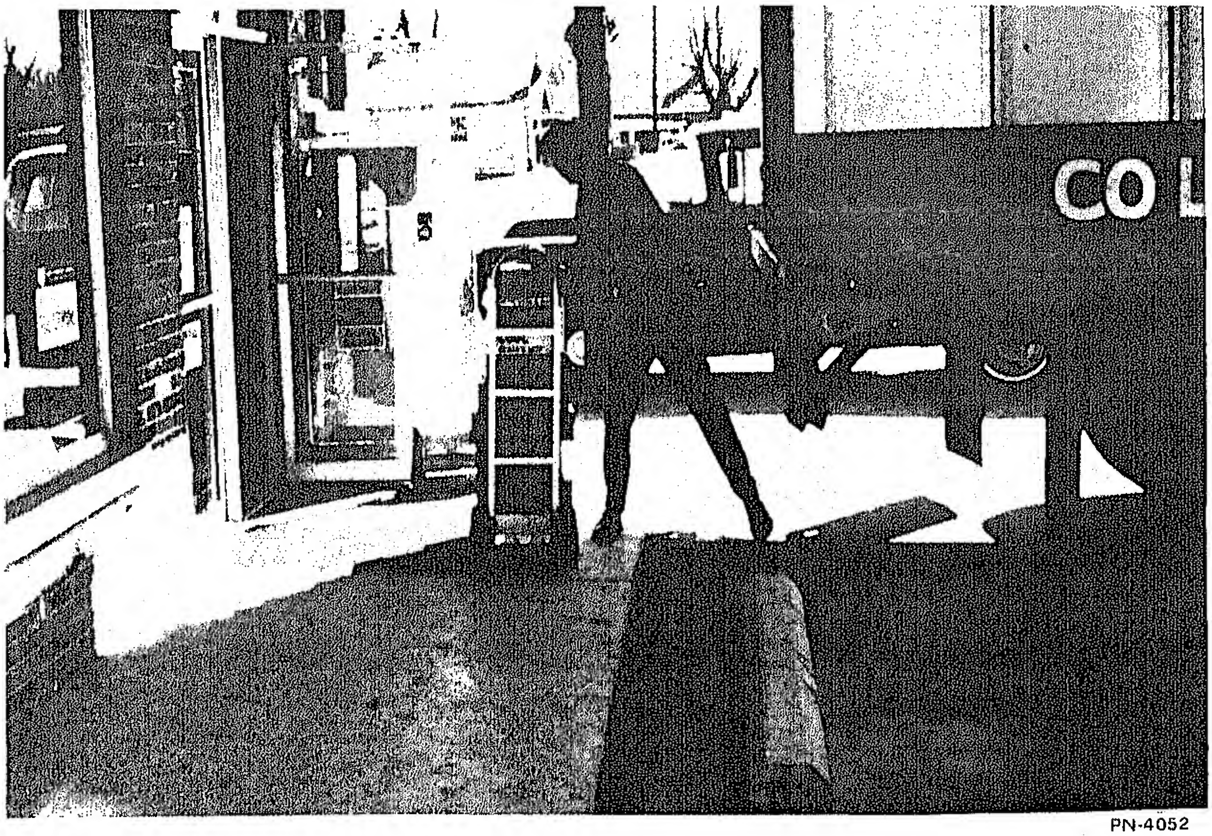
PN-4051

Figure 6.—Loaded collapsible cart being pulled in the store before shelf stocking.

4.6 seconds of the driver's time and 9.3 seconds of the store employees' time (two store employees were required). Converting the productivities to costs per 100 cases and charging $4.20 and $3.60 per hour, respectively, for the driver and store employees resulted in unloading costs of $1.47 per 100 cases.[6].

Several problems, however, are inherent in the conveyor-unloading method. First, the data were based on unloading at larger stores that provided two employees to help unload. Many small stores do not have employees to help unload; thus, the productivity data shown may

[6] Calculated as follows: (1.) Driver: $4.20 per hour÷ 3,600 seconds per hour = $0.00117 per second. $0.00117 per second x 4.6 seconds per case x 100 cases = $0.54 per 100 cases; (2.) Store employee: $3.60 per hour÷ 3,600 seconds per hour = $0.001 per second. $0.001 per second x 9.3 seconds per case x 100 cases = $0.93 per 100 cases; (3.) $0.54 per 100 cases+ $0.93 per 100 cases = $1.47 total per 100 cases.



PN-4052

Figure 7.—Loading a two-wheel handtruck from a hand-stacked delivery truck.

inflate actual unloading productivity at small stores. Second, most small stores receive their products through the customer entrance. A conveyor extending through the customer entrance would cause congestion and could possibly be a safety hazard to customers. The congestion would result from taking cases off the conveyor line and either stacking them or moving them to the proper shelf.

Finally, to use a conveyor, the delivery truck must be backed to the front of the store entrance if no back door for receiving was available; otherwise, the truck could stop anywhere in the store's parking lot. A delivery truck could possibly be delayed for a long time while the driver waited for customers to move their cars from the front of the store. Therefore, while conveyor unloading may be less costly under ideal unloading conditions such as the proper amount of store help and readily available access to the receiving door, many problems could greatly increase the cost of using this method.

Collapsible carts.—Unloading productivity with collapsible carts was 216 cases per man-hour, which was 76 cases more than with two-wheel handtrucks. Production with collapsible carts would be greater if truck-level docks were available at the store, because even with a power tailgate, the unloader still has to wheel the cart, into the store, and the congestion that might occur at a small store's front entrance would considerably reduce the deliveryman's productivity. Unloading costs of $2.22 per 100 cases with collapsible carts were 55 percent less than the unloading costs of $3.43 per 100 cases with two-wheel handtrucks (table 6).

EQUIPMENT COSTS

The costs for each of the four types of warehouse equipment studied were directly related to the type of selection line used. To move the selection equipment within the warehouse, four of the five order selection methods used tow tractors, and one method used high-lift trucks. Selected cases were placed on four-wheel selector trucks or collapsible carts. Two of the five methods used four-wheel selector trucks, and three of the five used collapsible carts.

Costs varied for each piece of equipment relative to the order selection method. The tractor and trailer costs represent the fixed costs for delivery equipment. The delivery cost analysis was not a complete analysis because the possibility of backhauling and its influence on overall cost was not considered in the study. Delivery costs would also be affected by traffic congestion, both on the streets and in the parking lots, customer congestion, and facilities and space available for trucks to maneuver and unload. Data used to develop the equipment costs discussed in the following section are shown in the appendix.

Long Selection Line

Four-wheel selector trucks.—Total costs for tow tractor, four-wheel selector truck, and delivery equipment (tractor and trailer) for this warehouse operation amounted to $2.53 per 100 cases for the 61- to 75-case order and increased to $2.80 for the less-than-25-case order (table 7). The delivery equipment cost of $2.25 per 100 cases was the major cause of this higher cost. Moreover, this delivery equipment cost remained constant for all orders where four-wheel selector trucks were used in warehousing, both in the long and in the short selection lines. The low productivity rate in order selection (table 1), coupled with a high cost of delivery equipment, resulted in total equipment cost for this method being the highest for all the methods studied.

Collapsible carts .—Total costs for tow tractor, collapsible cart, and delivery equipment (tractor and trailer) ranged from $1.48 per 100 cases for the more-than-75-case order to $1.71 for the less-than-25-case order. Compared with the four-wheel selector truck method, total

equipment costs decreased by approximately 67 percent for this handling method. This reduction can be attributed to the decrease in delivery equipment costs since they decreased to $1.16 per 100 cases for all warehouses that used collapsible carts, or to approximately one-half the costs of the four-wheel selector trucks. The delivery cost differences resulted from the more rapid loading and unloading of orders with collapsible carts, compared with hand loading and unloading with four-wheel selector trucks.

Short Selection Line

Four-wheel selector trucks.—The total warehouse and delivery equipment costs for this method of order selection ranged from $2.52 per 100 cases for the more-than-75-case order to $2.67 for the less-than-25-case order, a difference of $0.15. These variations were only minor comparing total equipment costs between the short selection line—four-wheel selector truck method and the long selection line—four-wheel selector truck method. Costs at $2.53 were identical for the 61- to 75-case order in both selection lines and had decreased by only 5 percent for the smallest order size in the short selection line. The increased order selector productivity in the smaller order sizes (table 3) accounts for the 5-percent decrease in costs.

Collapsible carts.—Equipment costs for this method of handling products were quite low. Total costs for the more-than-75-case order were $1.26 per 100 cases and gradually

TABLE 7.—*Summary of warehouse and delivery equipment costs per 100 cases for each selection method*[1]

Total order size	Long selection line							
	Tow tractor	Four-wheel truck	Tractor and trailer	Total	Tow tractor	Collapsible cart	Tractor and trailer	Total
	Dollars				Dollars			
More than 75	([2])	([2])	([2])	([2])	0.29	0.034	1.16	1.48
61 to 75	0.25	0.027	2.25	2.53	.33	.039	1.16	1.53
41 to 60	.32	.034	2.25	2.60	.36	.042	1.16	1.56
25 to 40	.37	.040	2.25	2.66	.45	.052	1.16	1.66
Less than 25	.50	.054	2.25	2.80	.49	.058	1.16	1.71

Total order size	Short selection line											
	Tow tractor	Four-wheel truck	Tractor and trailer	Total	Tow tractor	Collapsible cart	Tractor and trailer	Total	High-lift truck	Collapsible cart	Tractor and trailer	Total
More than 75	0.24	0.026	2.25	2.52	0.09	0.011	1.16	1.26	0.72	0.019	1.16	1.90
61 to 75	.25	.027	2.25	2.53	.10	.012	1.16	1.27	.82	.021	1.16	2.00
41 to 60	.29	.031	2.25	2.57	.11	.014	1.16	1.28	1.01	.026	1.16	2.20
25 to 40	.36	.039	2.25	2.65	.15	.018	1.16	1.33	1.17	.030	1.16	2.36
Less than 25	.38	.041	2.25	2.63	.25	.029	1.16	1.44	([2])	([2])	([2])	([2])

[1] Warehouse and delivery equipment costs, using tow tractors as an example, were calculated as follows: (a) $0.2465 equipment ownership and operating cost per hour ÷ 97 cases per man-hour x 100 cases = $0.25 per 100 cases; (b) 2.13 fixed tractor and trailer cost per hour ÷ 291 loading productivity + $2.13 fixed tractor and trailer cost per hour ÷ 140 unloading productivity) x 100 cases = $2.25 delivery equipment cost per 100 cases.

[2] No observations available for this order size in the firms studied.

increased to $1.44 for the less-than-25-case order, an increase of approximately 15 percent. Because order selector productivity with the batch selection technique (table 4) was higher than with the other methods, equipment costs were the lowest of all. Based on the results of this study, collapsible carts was the most desirable order selection method relative to equipment costs, in the warehouse operations studied.

Multilevel Selection Line

High-lift truck, collapsible cart.—For the high-lift truck and collapsible cart combination of order selection, total equipment costs were higher than for either of the two previous methods that used collapsible carts. Costs ranged from $1.90 per 100 cases for the more-than-75-case order to $2.36 for the 25- to 40-case order. The cost of the high-lift truck was the primary reason for the increased costs. As shown in table 7, costs for high-lift trucks were substantially higher than costs for the tow tractors used in the other warehouse operations.

Besides using high-lift trucks, the warehouse must also be specifically designed for them. Although its initial costs are slightly higher, the multilevel order selection method will reduce total warehouse costs if it can be used to handle low-volume grocery items and health and beauty aids, besides orders for small stores.

TOTAL COSTS

The total costs for servicing small retail stores for each of the five warehousing methods are shown in table 8 and figure 8.

Long Selection Line

Total costs for four-wheel selector trucks in the long selection line ranged from $12.10 per 100 cases for the 61- to 75-case order to $16.61 for the less-than-25-case order, a difference of $4.51. Total costs for collapsible carts in the long selection line ranged from $9.41 per 100 cases for the more-than-75-case order to $13.04 for the less-than-25-case order. The cost for collapsible carts was $1.96 less (19 percent) for the 61- to 75-case order and $3.57 less (27 percent) for the less-than-25-case order than the cost for four-wheel selector trucks in the long selection line. As indicated earlier in the study, the cost and productivity of using four-wheel selector trucks or collapsible carts will not vary greatly until the time for loading and unloading the delivery trucks, and it may be the only advantage in implementing collapsible carts instead of four-wheel selector trucks in a long-selection-line warehouse.

Short Selection Line

Total costs for the short selection line—equipment in four-wheel selector truck method were as much as 15 percent lower than that of similar equipment in the long selection line. Costs ranged from $11.84 per 100 cases for the more-than-75-case order to $14.47 for the less-than-25-case order. The lower order selection cost shown in table 3 reduced total cost with this method, compared with total cost with the long selection line. This lower cost is the direct result of using a short selection line (fig. 8). Except for selection costs, which directly affect equipment costs, all other costs with four-wheel selector trucks are identical in both long- and short-selection-line warehouses.

The short selection line—collapsible cart method had the lowest total cost. Total costs ranged from $5.82 per 100 cases for the more-than-75-case order to $8.66 for the less-than-25-case order. Costs were more than $5 lower in each of the order sizes, compared with the short selection line—four-wheel selector truck method and averaged about $4 less than costs with the long selection line—collapsible cart method. Order selection cost was lower because batch selection was used thereby reducing total costs greatly.

Multilevel Selection Line

With the multilevel selection line—collapsible cart method, total costs were higher than with the short selection line—collapsible cart

TABLE 8.—*Total cost for servicing small retail stores from wholesale warehouses*[1]

Order size	Total cost per 100 cases									
	Long selection line				Short selection line					
	Tow tractors	Four-wheel trucks	Tow tractors	Collapsible carts	Tow tractors	Four-wheel trucks	Tow tractors	Collapsible carts	High-lift trucks	Collapsible carts
Cases	*Dollars*		*Dollars*		*Dollars*		*Dollars*		*Dollars*	
More than 75	NA		9.41		11.84		5.82		7.54	
61 to 75	12.10		10.14		12.01		5.97		8.04	
41 to 60	13.22		10.58		12.81		6.21		8.95	
25 to 40	14.26		12.23		14.07		6.95		9.71	
Less than 25	16.61		13.04		14.47		8.66		NA	

[1] Includes cost for physical handling only.

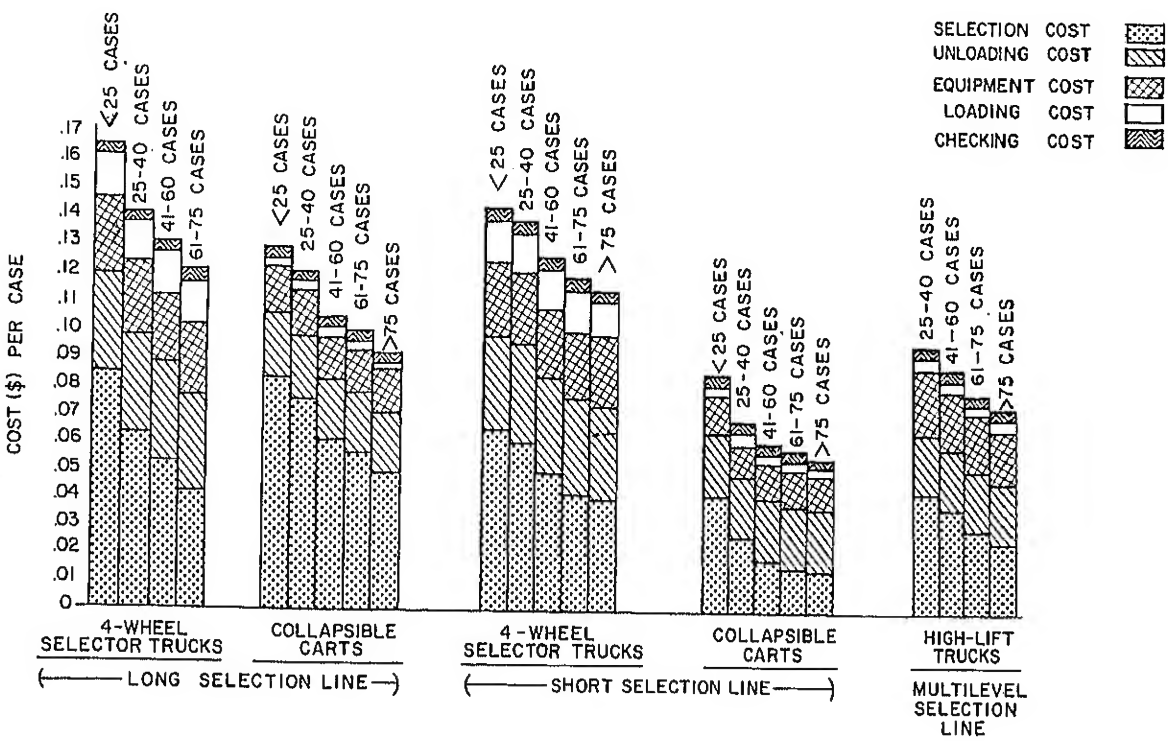


Figure 8.—Summation of measured costs by order size for five warehousing methods.

method, but they were still lower than the order selection methods. Total costs with the more-than-75-case order ($7.54 per 100 cases) were 30 percent greater than with the short selection line—collapsible cart method ($5.82 per 100 cases), but remained more than $4 less than total costs with the four-wheel selector truck method. Costs were $9.71 per 100 cases for the 25- to 40-case order, or $2.76 (40 percent) more than with the short selection line—collapsible cart method.

If a warehouse, operating with a long selection line and four-wheel selector trucks, shipped 500,000 cases per year for the 61- to 75-case order (an average annual shipment), the cost would be $6,050,000 and for the less-than-25 case order, $8,305,000 which had the highest cost of the 5 selection methods. To ship the same amount of cases annually using the lowest total-cost method (short selection line—tow tractor-collapsible cart) and the same sizes (61- to 75-case orders, less-than-25-case orders, etc.), costs would decrease to $2,985,000 and $4,330,000, respectively, for an average reduction in costs of approximately 98 percent.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of this study, grocery wholesalers should group those items regularly ordered by small stores in a short selection line and batch assemble and ship orders on collapsible carts. However, the best method is the one most adaptable to existing facilities and operating techniques.

Management should use five basic steps to determine which method to adopt. The first step is to study existing facilities and equipment to determine what is available. The second step is to determine what additional equipment and facilities would be needed to implement the particular method. The third

step is to determine the cost of additional equipment and facilities. The fourth step is to estimate, through management experience and personal judgment, the likely future costs of labor and equipment. The fifth and final step is to balance the costs for additional equipment and facilities against the potential savings of the proposed method.

Establishing a short selection line, regardless of the equipment used, should be management's primary consideration in handling orders for small stores. Selection costs were the highest costs for servicing such orders in each of the methods studied. However, selection costs in a short-selection-line facility decreased by as much as 35 percent from costs in a long-selection-line facility (fig. 8). This reduction occurred without the batch selection technique and without the use of high-lift equipment. Therefore, implementing a short selection line will noticeably reduce selection costs for smaller order sizes.

Two possible alternatives for establishing a short selection line in a facility that has operated exclusively with a long selection line are shown in the layouts in figures 9 and 10.

The layout shown in figure 9 could be implemented in an existing warehouse with the least difficulty, because most small store items can be grouped near the center aisle. With this layout, the order selector obtains items for the small stores from three pallet-rack bays on either side of the center aisle. Thus, only the items handled by small stores would have to be moved into three pallet-rack bays on either side of the center aisle.

The layout shown in figure 10, however, would require grouping all items handled by small stores in aisles designated for such orders. This grouping would impose a more difficult problem than the grouping shown in figure 10 in the overall warehouse layout and may result in duplicating items in the warehouse. This problem may be compounded if the warehouse layout is similar to the store layouts with family groupings.

Another likely alternative for reducing cost in warehousing would be to change the type of order selection equipment (four-wheel selector trucks and collapsible carts) used in the warehouse. Next to selection cost, which directly influenced equipment cost, costs for unloading and loading were the second and third highest costs, respectively, in servicing orders for small retail stores. If the long selection line four-wheel selector truck method were converted to collapsible carts, unloading and loading costs would be reduced by $2.31 per 100 cases, or near the costs of a short selection line operation (fig. 8). The same reduction in costs would appear if a changeover (from four-wheel selector trucks to collapsible carts) occurred in the short selection line.

Although multilevel selection of small store orders did not have the lowest cost of the various methods studied, this method is another alternative that management should consider. However, when considering the use of multilevel order selection, management should think in terms of including health and beauty aids and low-volume grocery items, as well as items for the small retail stores, in the multilevel selection area.

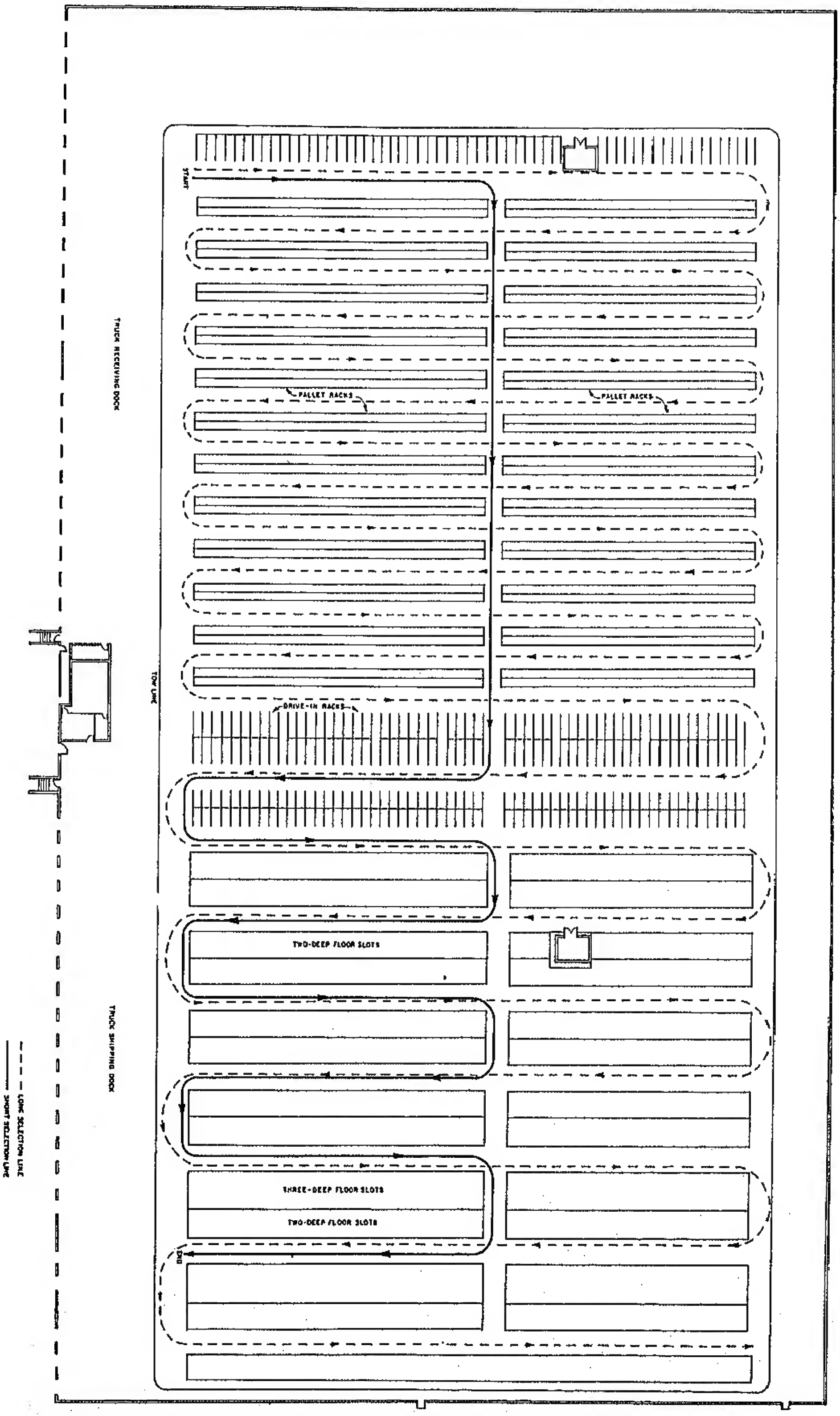


Figure 9.—Layout for a short selection line not used in the firms studied but ideal for this analysis.

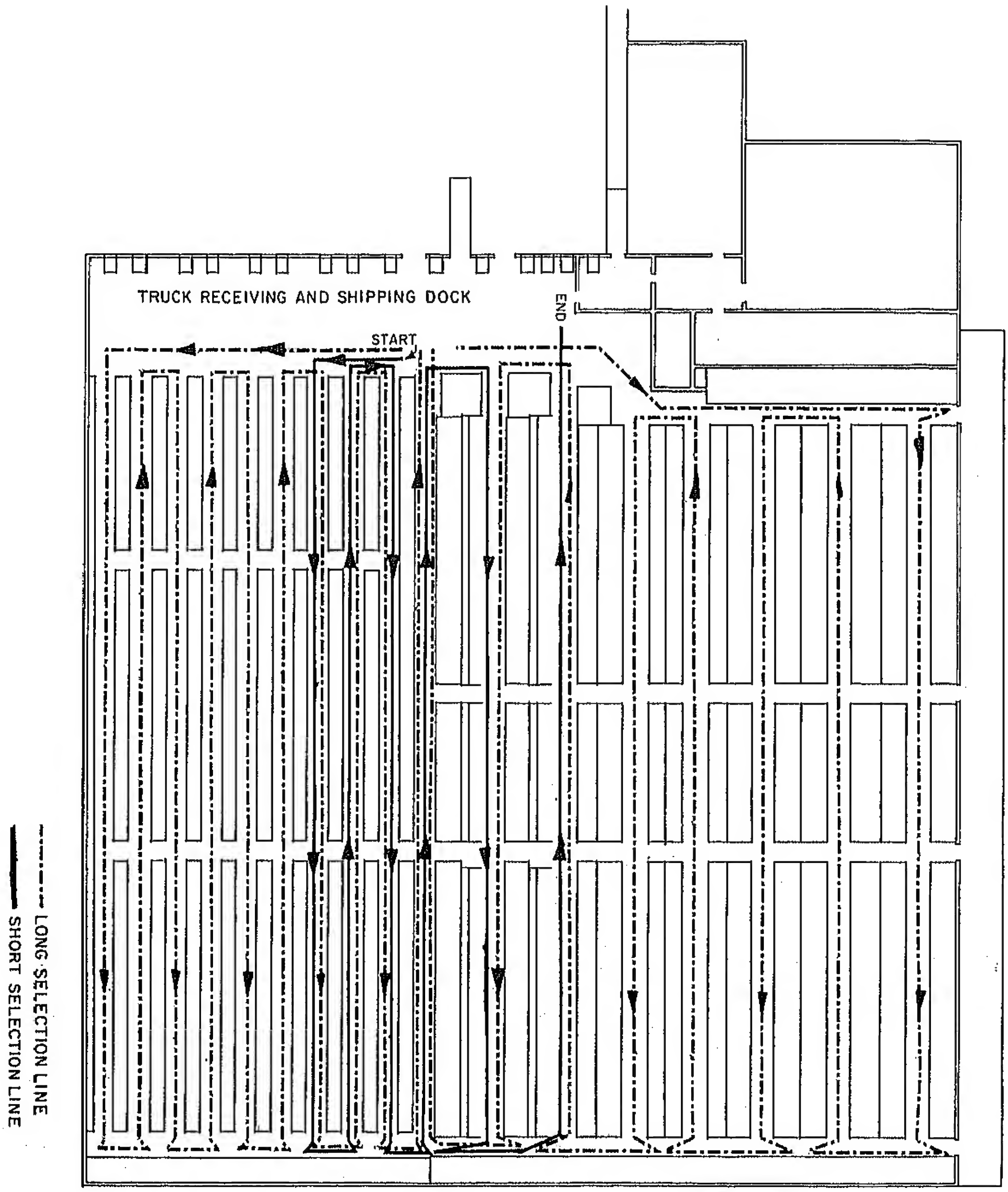


Figure 10.—Layout for a typical short selection line. The short-selection-line area occupies approximately one-third of the total selection area.

APPENDIX

TABLE 9.—*Cost of equipment, ownership, and operation*

Tow tractors:			
Unit cost		$2,200.00	
Depreciation, 10 years	$220.00		
Interest, 6% x 2,200	132.00		
Insurance and tax, 4% x 2,200	88.00		
Ownership cost, annual	440.00		
Electricity, 2,000 x 0.01	20.00		
Maintenance, 1.5% x 2,200	33.00		
Operating cost, annual	53.00		
Total annual ownership and operating costs			$493.00
Total ownership and operating costs per hour[1]			.2465
Four-wheel selector trucks:			
Unit cost		150.00	
Depreciation, 5 years	30.00		
Interest, 6% x 150	9.00		
Insurance and tax, 4% x 150	6.00		
Ownership cost, annual	45.00		
Maintenance, 5% x 150	7.50		
Operating cost, annual	7.50		
Total annual ownership and operating costs			52.50
Total ownership and operating costs per hour			.0263
Collapsible carts:			
Unit cost		165.00	
Depreciation, 5 years	33.00		
Interest, 6% x 165	9.90		
Insurance and tax, 4% x 165	6.60		
Ownership cost, annual	49.50		
Maintenance, 5% x 165	8.25		
Operating cost, annual	8.25		
Total annual ownership and operating costs			57.75
Total ownership and operating costs per hour			.0288
High-lift selector trucks:			
Unit cost		10,000.00	
Depreciation, 10 years	1,000.00		
Interest, 6% x 10,000	600.00		
Insurance and tax, 4% x 10,000	400.00		
Ownership cost, annual	2,000.00		
Electricity, 2,000 hour @ 0.01	20.00		
Maintenance, 2% x 10,000	200.00		
Operating cost, annual	220.00		
Total annual ownership and operating costs			2,220.00
Total ownership and operating costs per hour			1.110
Period of usage .... 2,000 hours			

[1]Total annual ownership and operating costs ÷ time of use (2,000 hour) = total ownership and operating costs per hour.